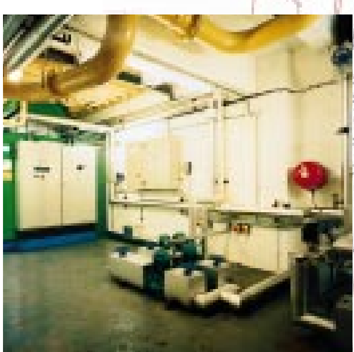
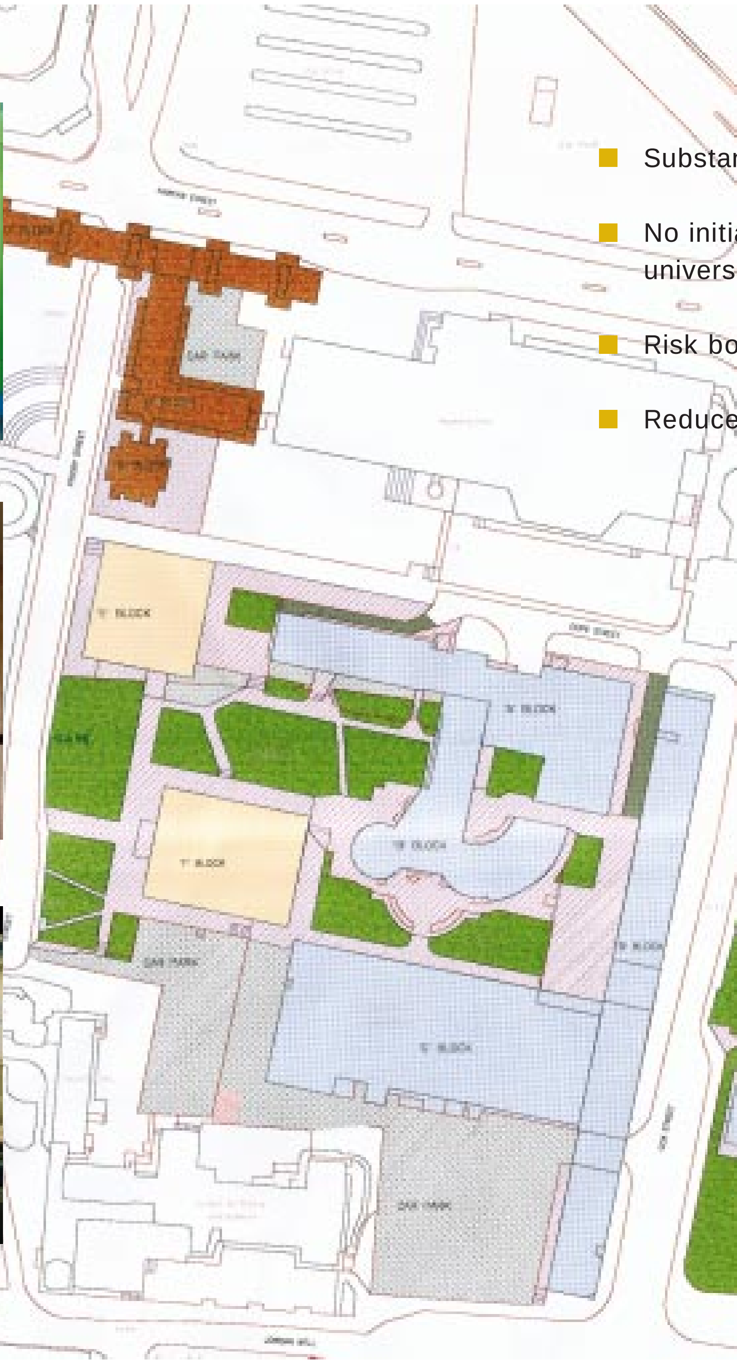
GOOD PRACTICE CASE STUDY 373

The economic benefits of using combined heat and power at Coventry University





- Substantial financial savings
- No initial cost to the university
- Risk borne by the supplier
- Reduced CO_2 emissions

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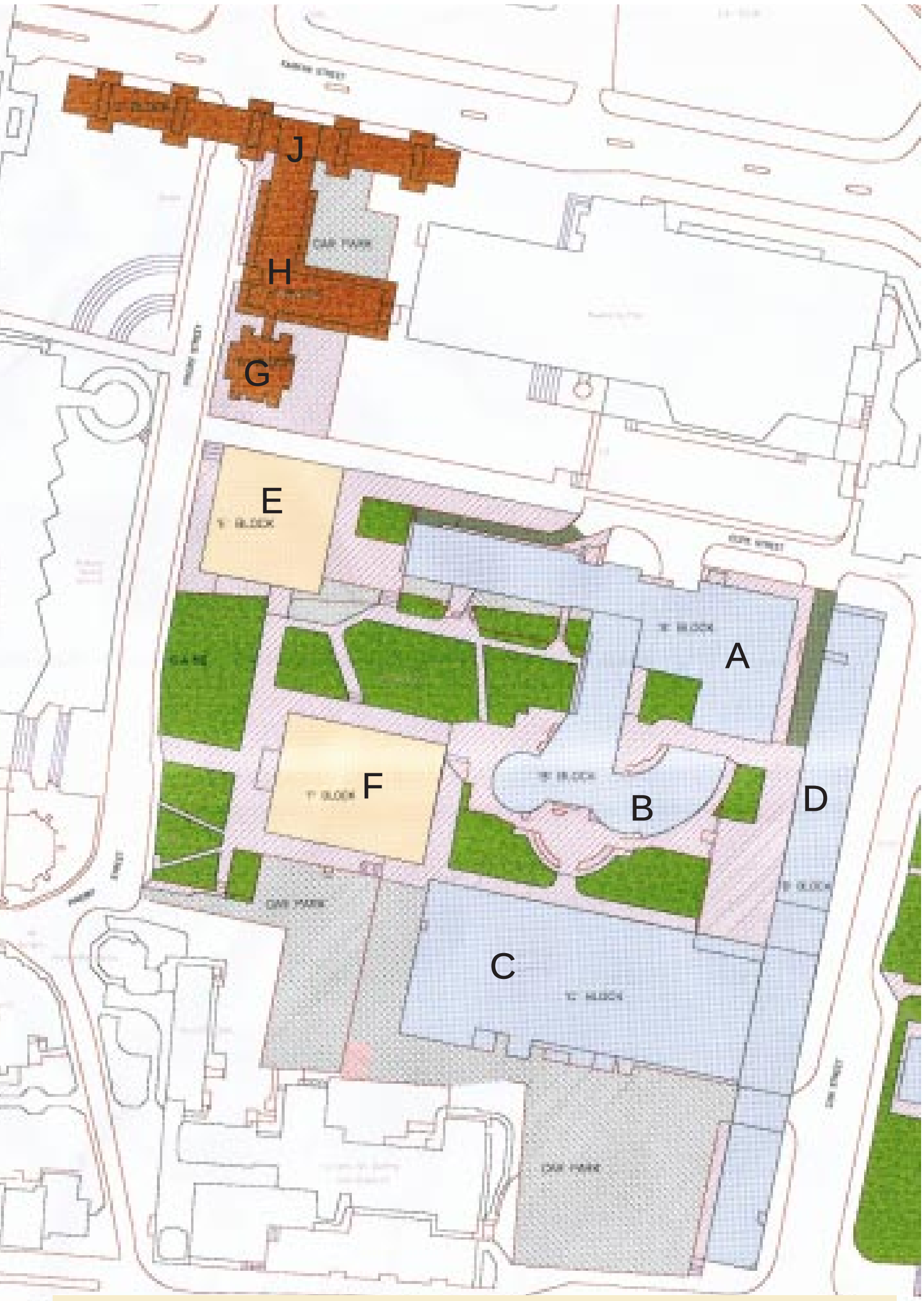
BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

INTRODUCTION



A	Health Sciences	F	Administration
B	Humanities	G, H, J	Halls of residence, plus communal kitchens, laundries and refectory
C	Engineering		
D	Sciences		
E	Students Union		

Figure 1 Plan of Coventry University Campus

'Combined heat and power provides Coventry University with substantial savings in operating costs, while making a real contribution to our environmental performance. The equipment was installed at the supplier's cost and risk, and within three years we decided to purchase outright and thereby achieve greater savings. We are delighted with the outcome.'

Vice-chancellor Dr Goldstein (right) with Nedalo business development manager Mr Jeff Pearson

INTRODUCTION

Coventry University is a city-centre site in the shadows of Coventry Cathedral. It consists of 26 buildings totalling 90 000 m^2 in area.

It achieved university status in 1989, having been a polytechnic since 1972, which itself had progressed from the Lanchester College of Technology. Coventry University caters for 15 000 students, covering a wide range of courses from Health Sciences to Industrial Design. It currently has residential accommodation for 2000 students in various types of buildings from purpose-built halls to domestic houses.

This Case Study describes how Coventry University investigated the feasibility of converting to a combined heat and power (CHP) system, the economics of the purchase/lease options and the financial benefits that accrued from the installation of CHP. It also demonstrates the environmental benefits of CHP in producing a net reduction in the emission of carbon dioxide (CO_2).

THE COMBINED HEAT AND POWER OPTION

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Until 1994, Coventry University obtained its electricity and heating from 'conventional' sources, ie electricity from the public electricity supplier (PES) and heating from gas-fired boilers.

The energy manager and the estates director had been aware since the mid-1980s that the site had potential for CHP, having learned about CHP from exhibitions and seminars run by the Department of the Environment, Transport and the Regions (DETR).

Contract history

The University's estates department decided to investigate the case for CHP. Their conclusions, which highlighted the financial and environmental benefits of CHP, were presented to the Vice-Chancellor.

As a result £2000 was granted for a more detailed feasibility study. A detailed assessment by British Gas came to the same conclusions as the internal assessments, confirming that CHP would be an economic and environmentally friendly choice.

In sizing the unit, the University tried to find the right balance – if the unit is very small it will certainly run, but may not be the most economic or energy-efficient choice. Conversely, an oversized unit will not run sufficient hours per year to achieve adequate savings. The campus electricity main, with over 1000 kW_e base-load, meant that there would be a ready load for the CHP units to supply. Furthermore, two of the University's six boiler houses had been operating for around 5000 hours, so the heat load was sufficient to justify installing CHP.

The successful tenderer, Nedalo, proposed two separate CHP installations (at sites labelled A and G in figure 1 on page 2), each costing around £250 000, and also offered fully financed packages under its scheme. The University decided to proceed with both sites under the financed scheme, retaining the option to buy one or both of the units at a later date. The installation was completed in December 1994.

The contract was let to British Gas as the main contractor specifying Nedalo packaged units. The University employed a clerk of works to represent its interest, and funding for this was included in the financed CHP package. The contract works caused little disruption – some planning was required for turning off local electricity supplies briefly for works, and for small-scale structural works for the G Block housing, which occurred at exam time. These aspects required careful liaison with contractor and supplier.

Nedalo was also the maintenance contractor and, following purchase of the CHP units, this remains the case.

Apart from Nedalo, there are other suppliers of similar energy services in the market. Please contact the Combined Heat and Power Association (CHPA) for an industry directory (tel 020 7828 4077 fax 020 7828 0310) or contact BRECSU or ETSU, who may be able to provide more details (contact details are on the back cover).

LAYOUT AND OPERATION

The A Block CHP unit, located in the original central campus, is connected to a local heating main serving the science and engineering buildings, the students union and an administration building (Blocks A to F). The unit is located in the boiler room under Block A.

The G Block unit is connected to heating circuits which serve three halls of residence and a refectory (Blocks G to J). The unit is located in a plant room off a basement access roadway.

WHAT IS CHP?

Combined heat and power (CHP) is the generation of thermal and electrical energy in a single process. In this way optimum use can be made of the energy available from the fuel. CHP installations typically convert between 70% and 80% of the energy in the fuel into electrical power and useful heat. This compares very favourably with conventional power generation which provides electrical power to the point of use at an efficiency of around 30-40%.

The value of the electricity and heat produced by a CHP unit is greater than that of the fuel consumed. In particular, the value of a unit of electricity can be up to five times that of a unit of fuel. So long as the difference offsets capital and maintenance costs, savings are made. In order to maximise savings from the initial capital investment, running hours should be as long as possible.

***Figure 2** A Block CHP unit (left) and control panel*

COSTS

Figure 3 G Block CHP unit

The units, both rated at 300 kW_e (electrical power), generate electricity at normal mains voltage. The electricity is distributed across the campus via the University's high-voltage electricity main. The units' combined electrical output of 600 kW_e is well below the site electricity baseload of around 1000 kW_e .

The units have on-board controllers which are connected to the University's building management system (BMS). The controllers display key operating parameters (such as kW_e of electricity being generated), and provide status, diagnostics and fault reporting to the BMS, and, via the public telephone network, to the maintenance contractors.

The units are provided with heat-dump heat exchangers so that they can be run at times of low heat load. Since electricity has a higher value than heat, a certain amount of heat dumping is often the most economic option. Provided the proportion of heat dumping remains smaller than that expelled to the atmosphere by a conventional power station of equivalent electrical capacity, this is also the most environmentally beneficial solution. The economics of running the units with a heat dump was assessed in relation to gas and electricity prices and other operating costs.

The BMS programming included a mode of operation for times of low heat load. For example, in the short summer recess, the A Block unit runs as normal but the G Block heat load is low and the unit is normally run for only 4-6 hours per day.

The estates department has maintained a weekly record of operating output and financial performance since the units were installed.

COSTS

The initial installed cost, borne by the equipment supplier Nedalo, was £230 000 for the A Block unit. Of this, approximately £120 000 was for the CHP package and the remainder for installation. The G Block contract cost was higher at £250 000, but it also catered for standby electricity generation which helped the University avoid renewal of its ageing standby generation and boiler plant – an effective saving of £70 000.

The quotation included options for initial purchase or for purchase between one and five years after installation. In the event, the G Block unit was purchased after eight months and the A Block unit some two years later.

The finance package, based on a 10-year fixed term, works as follows.

- All initial costs are borne by the supplier, including further investigations, equipment supply, installation and commissioning.
- The University pays (in the normal way) for gas supplied to the CHP units.
- The University pays the CHP supplier an agreed cost (which is lower than that from the public supply) for each kWh of electricity generated by the CHP plant and used by the University. The University has a commitment to take electricity for 5500 hours of CHP operation a year.
- The University uses the heat generated by the CHP plant, at no further cost.
- The supplier provides all-inclusive maintenance for the duration of the project.
- The supplier guarantees 91% average availability of the units.
- The University has no capital expenditure and therefore no finance costs.

The purchase option works as follows.

- A schedule of agreed costs is provided in the initial quotation, for purchase after one to five years of the 10-year contract. The cost for the A Block unit after two years was £170 000.
- The quotation includes an all-inclusive annual maintenance cost (fixed except for inflation in line with the retail price index) for the remainder of the 10-year period after the CHP unit is purchased. The cost encompasses minor and major servicing, call-outs and repairs. The current annual cost is approximately £11 000 for each CHP unit.
- After purchase, there are no more payments to the suppliers for each kWh of electricity generated.
- After purchasing the units, the University will have finance costs which should be taken into account.

COSTS

The only further costs experienced by Coventry University were:

- initial investigations before the contract was given to Nedalo (this amounted to various uncosted internal investigations including a final year project by a student, and the assessment by British Gas for £2000 in the early 1990s)
- uncosted estates department staff time (the energy conservation officer spends one to two hours a week reading meters and updating records).

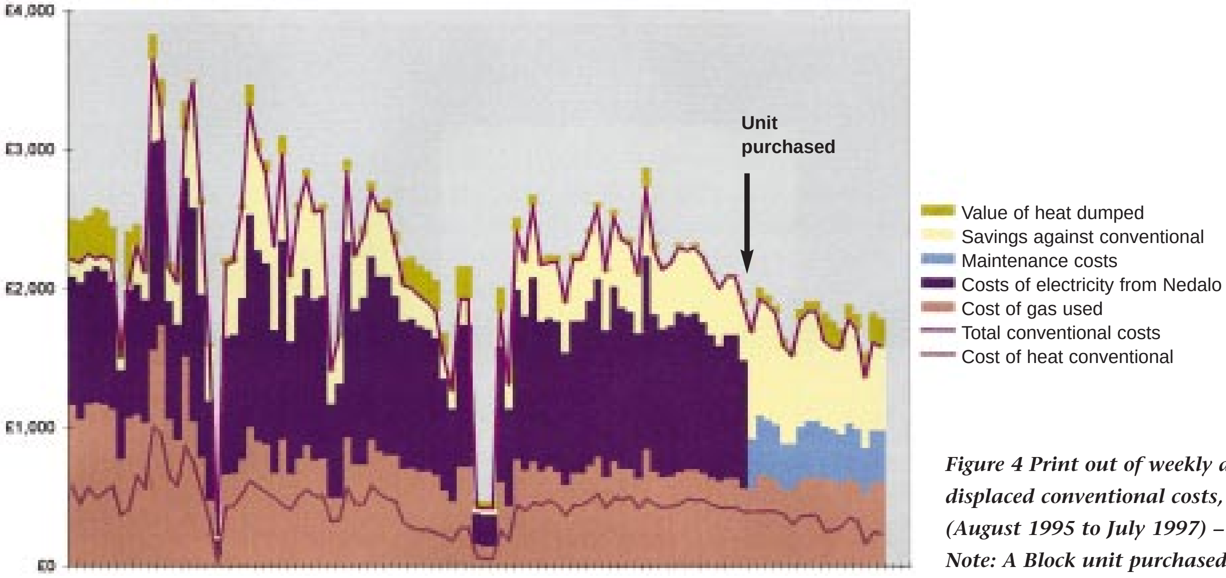

Figure 4 Print out of weekly actual costs, displaced conventional costs, and savings (August 1995 to July 1997) – A Block
Note: A Block unit purchased April 1997

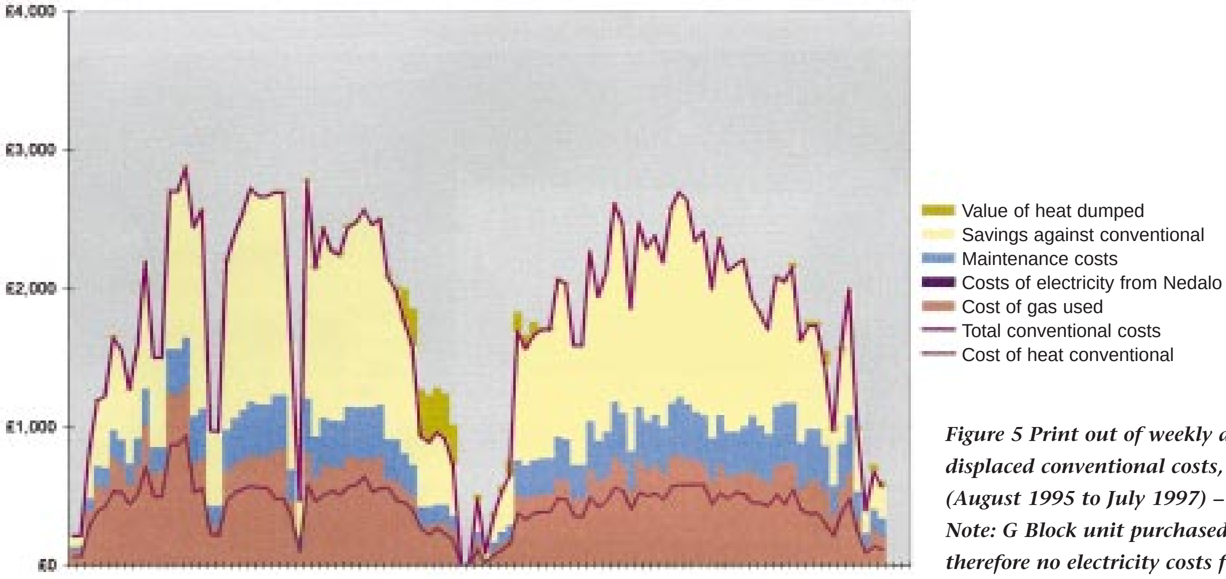

Figure 5 Print out of weekly actual costs, displaced conventional costs, and savings (August 1995 to July 1997) – G Block
Note: G Block unit purchased August 1995, therefore no electricity costs from Nedalo

PERFORMANCE

PERFORMANCE

In 1996/7 the A Block CHP unit ran for 5300 hours (14.5 hours per day), achieving 96% availability. The annual savings (table 1) at this time, under the finance scheme, were around £22 000. Following purchase of the CHP unit, annual savings have approximately doubled.

The G Block CHP unit ran for 5060 hours in 1996/7 (13.6 hours per day) achieving 92% availability. The annual savings (table 2) for 1996/7 were over £55 000, since when electricity prices have fallen and so reduced the value of the electricity generated.

Figures 4 and 5 on page 5 demonstrate the savings for CHP, and figure 4 also shows the additional savings made following purchase.

Maintenance is required at 1000-hour intervals, primarily to change oil filters and spark plugs, although longer-life spark plugs are being developed. Should servicing be required prior to this, it would become evident as the electrical power output would decline.

The use of the heat dump is lower in G Block – it is run less in summer and has extended heating loads in the rest of the year. The value of heat dumped in 1996/7 is 4% of total energy value (20% of heat used) for A Block and 1% of total energy value (5% of heat used) in G Block. Together, the A and G block CHP units generate an average of more than 2 600 000 kWh of electricity each year, resulting in savings of over 1000 tonnes of CO_2 each year, contributing to the Government's climate change objective.

Table 1 Summary of A Block annual performance for 1995/6, 1996/7, and 1997/8

Note: Savings in tables 1 and 2 are derived from the difference between:

- the cost incurred producing heat and power from the installed CHP plant
- the cost which would otherwise have been incurred buying electricity from the PES and obtaining heat from boilers.

Although the tables show figures used for simple payback calculations only, calculations including the cost of finance and the time value of money were also carried out.

Annual summary A Block	1995/6	1996/7	1997/8
CHP maintenance cost	£0	£0	£11 948
CHP electricity cost	£48 403	£53 391	£0
Gas cost	£48 149	£34 188	£29 636
Total CHP cost X	£96 552	£87 579	£41 584
PES electricity value	£81 622	£86 340	£65 451
Value of heat used	£27 441	£20 289	£16 767
Displaced boiler maintenance cost	£2727	£3030	£3426
Total cost or value Y	£111 790	£109 659	£85 644
Savings Y – X	£15 238	£22 080	£44 060

Note: A Block unit purchased 01/04/1997

Table 2 Summary of G Block annual performance for 1995/6, 1996/7 and 1997/8

Annual summary G Block	1995/6	1996/7	1997/8
CHP maintenance cost	£6601	£11 339	£11 835
CHP electricity cost	£13 961	£0	£0
Gas cost	£39 370	£28 497	£29 848
Total CHP cost X	£59 932	£39 836	£41 683
PES electricity value	£64 864	£71 313	£64 832
Value of heat used	£28 278	£21 365	£20 575
Displaced boiler maintenance cost	£2502	£2777	£4404
Total cost or value Y	£95 644	£95 455	£89 811
Savings Y – X	£35 712	£55 619	£48 128

Note: G Block unit purchased 01/08/1995

FINANCE

FINANCE

Coventry University avoided spending its own capital and minimised its exposure to risk by choosing the equipment supplier finance route for obtaining its CHP plant – this meant that the supplier bore the initial cost of the installation. This enabled the University to proceed with two units instead of just one unit as planned. The supplier therefore owned and operated the units in the University premises and obtained income by selling electricity to the University.

The supplier also bore the risk of the units not achieving their expected savings. The University's only obligation was that there should be sufficient heat load for the units to operate for the agreed number of hours per year (5500 hours).

The supplier was responsible for all maintenance and replacement at no extra cost and the University only paid for gas used and electricity generated. Had breakdowns caused the availability to drop beneath the contracted limit, 91% in this case, the supplier would have incurred cost penalties in the form of reduced payment for electricity generated.

Under this scheme the CHP units are priced at the end of every full year, and the units can be purchased at any time. The terms of purchase and subsequent costs are set down in a schedule in the original contract. Coventry University exercised the purchase option on the two units after eight months and two-and-a-half years respectively.

Following the purchase, the customer owns and operates the units, but still bears no risk for maintenance/repair for the remaining duration of the original 10-year contract. This is because the all-in maintenance and repair charge is set down in the original contract and fixed subject to retail price index (RPI) linked inflation. Thus the maintenance contract is still with the supplier, and there is a single point of contact for maintaining availability at the guaranteed level.

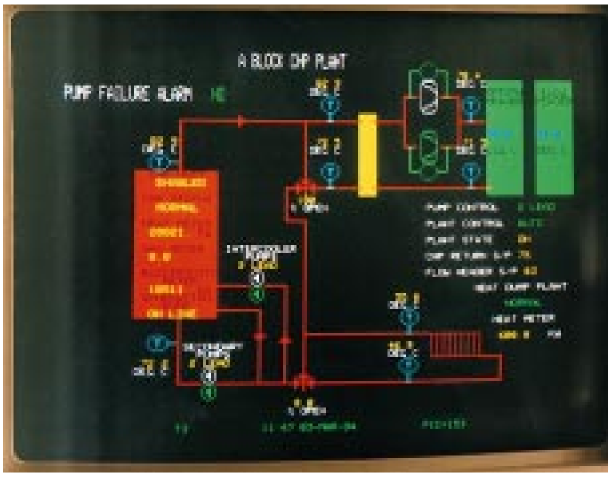

Figure 6 Schematic of A Block CHP installation

FURTHER INFORMATION

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Details of suppliers of CHP systems can be obtained from the Combined Heat and Power Association, 35-37 Grosvenor Gardens House, London SW1W 0BS. Tel 020 7828 4077.

DETR ENERGY EFFICIENCY BEST PRACTICE PROGRAMME PUBLICATIONS

The following Best Practice programme publications are available from BRECSU Enquiries Bureau. Contact details are given below.

Good Practice Guides

1 Guidance notes for the implementation of small-scale packaged combined heat and power
3 Introduction to small-scale combined heat and power
176 Small-scale combined heat and power for buildings
204 Combined heat and power (CHP) in universities
234 Guide to community heating and CHP – commercial, public and domestic applications

Good Practice Case Studies

150 Energy management. Manchester University
335 Investment in energy efficiency at the University of Warwick

The following Best Practice programme publications are available from ETSU Enquiries Bureau. Contact details are given below.

Good Practice Guides

115 An environmental guide to small-scale combined heat and power
226 The operation and maintenance of small-scale combined heat and power

Good Practice Case Studies

292 Long-term operation of combined heat and power in university halls of residence
351 CHP at a university campus – The University of Liverpool

(Note that ‘small-scale’ refers to CHP plant up to 1 MW_e – it therefore covers most university installations.)

The Government’s Energy Efficiency Best Practice programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice programme are shown opposite.

Visit the website at www.energy-efficiency.gov.uk

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Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

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Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Introduction to Energy Efficiency: helps new energy managers understand the use and costs of heating, lighting, etc.

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